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# Modeling a Business Process and Querying the Resulting Database: Analyzing RFID Data to Develop Business Intelligence

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**ABSTRACT:** This case supports the high-level objective of learning to model business situations to design databases and query them to solve business problems. Students analyze Radio Frequency Identification (RFID) and related fulfillment data to develop business intelligence for a grower of bedding plants selling to big-box retailers. Students prepare a business process diagram to understand the business process; identify objectives for detecting and correcting data errors and analyzing business performance; construct a Resource, Event, Agent (REA) diagram to specify a database design; implement the database and query it to satisfy business objectives; communicate results; document data error correction procedures; and prepare adjusting journal entries. The case is appropriate for students with moderate database querying proficiency. The case's managerial and financial accounting and internal control implications make it suitable for courses in Accounting Information Systems (AIS) and database systems for advanced undergraduate students and in AIS, database, and managerial courses for master's students. The data are supplied in Microsoft Access® databases.

**Keywords:** business process modeling; cost analysis; data quality; database querying; performance analysis; REA; RFID.

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## I. LEARNING OBJECTIVES AND CASE DESIGN

### Querying to Assure Data Quality and Analyze Business Performance

The success of data warehouses in providing information about business operations to support decisions has increased expectations that decision makers will retrieve information from databases and analyze it whenever a compelling problem or a promising opportunity arises (Cooper et al. 2000; Wixom and Watson 2001; Speier and Morris 2003). Accountants, especially, are expected to query transaction data generated about business operations for investigating business situations to develop insights for improving the business (Borthick 1992; McKinnon and Bruns 1992; Klamm and Weidenmier 2005). This shift to users retrieving and analyzing data themselves sets up new demands for accountants to develop process modeling, analysis, and querying skills (McCollum 2002; Fennel 2003; Jackson 2004). This case supports the high-level objective of *learning to model business situations to design databases and query them to solve business problems.* The specific objectives of this case are to detect and correct data recording errors to assure data quality and analyze business performance to identify potential improvements in operations.

The case features correcting and analyzing data collected from radio frequency identification (RFID) tags as a way to track objects in a supply chain (Bose and Pal 2005). The specific context for the case is a plant grower's need to improve operations by making sense of RFID data representing the movement of flats of plants and the carts transporting them (Sullivan 2004). The context is enabled through a conversation about the situation in text or audio form; databases with tables containing data from RFID sensing of flat and cart movement, fulfillment-related data including orders and inventory, and a chart of accounts; and a reporting template. Students analyze transaction-level data to detect and correct RFID recording errors, develop insights for managing the business, and prepare adjusting journal entries based on operational results. The case illustrates the plight of companies attempting to integrate disparate systems that were developed independently. The authentic business context results in students needing to address the managerial accounting issue of costing for cart usage, internal control aspects in the form of data quality lapses, and the financial accounting need to determine appropriate adjusting journal entries stemming from operational results.

### Learning Objectives

The high-level learning objective is to *learn to model business situations to design databases and query them to solve business problems.* In the context of this case, students detect and correct data recording errors to assure data quality and analyze business performance to identify potential improvements in operations. The case achieves these objectives through the activities of:

1. Preparing a business process diagram (BPD) (BPMI 2004; White 2004) as a means of understanding the business process,
2. Developing objectives for assuring data quality and analyzing business performance for subsequently directing database querying,
3. Constructing a database model in the form of a Resources-Events-Agents (REA) diagram (McCarthy 1982; Dunn and McCarthy 1997) and implementing it in a relational database with the supplied data,
4. Querying the database to satisfy the objectives developed above for assuring data quality and analyzing business performance,

5. Documenting querying procedures for clerical staff to allow query results to be used routinely,
6. Preparing adjusting journal entries consistent with query results,[1]
7. Communicating the results in a report, and
8. Optional: Evaluating other students' work.

These objectives operationalize the process of identifying analysis needs, preparing adjusting journal entries, and continuing the project through to communicating results. The case illustrates how accountants can make sense of a new situation to provide information for improving operations consistent with expectations that accountants provide information for management (McKinnon and Bruns 1992; Borthick 1996; Speier and Morris 2003).

**Learning Theory: Situation Model Building**

In the theory of situation model building (Zwaan and Radvansky 1998; Barsalou 1999), the best preparation for action is having constructed one's own mental situation models in analogous prior situations. This case constitutes a prior situation for future situations requiring skills in modeling business processes, designing and implementing databases, and querying databases to solve business problems. To construct their own situation models, learners make inferences and elaborations as they encounter new information in the situation. In this theory, learners demonstrate comprehension of a problem by constructing a coherent situation model representing it (Johnson-Laird 1983; van Dijk and Kintsch 1983; Gernsbacher 1997; Graesser et al. 1997; Zwaan and Radvansky 1998). The process of constructing situation models requires one to make inferences and elaborations as new information about the situation emerges. More learning occurs when situations are hard rather than easy to understand because easy-to-understand situations do not prompt elaborations or inferences (Myers et al. 1987). Thus, modeling easy-to-understand situations provides less opportunity for learning than more challenging situations (Gernsbacher 1997; Zwaan and Radvansky 1998).

The case was designed for its comprehension to be hard enough to prompt learners to make the substantial inferences and elaborations required to make sense of a business situation. Preparing the business process and REA diagrams ensures that students make their understanding of the situation explicit, which enables the completeness and correctness of their understanding to be assessed, which permits them to refine their process skills. Constructing the queries requires learners to think through (1) sources and purposes of the data files, (2) how the data were recorded and potential sources of data errors, (3) the objectives for using the data, and (4) how the data could be analyzed to inform business operations. Understanding these matters requires insights that come one at a time as learners integrate knowledge from the conversation, the data tables, and other materials into their existing situation models (Gernsbacher 1997; Zwaan and Radvansky 1998). Although experienced business people make these kinds of inferences almost automatically, inexperienced business people, e.g., learners in classroom settings, tend to miss important relationships. The inferences and elaborations are subtle, but they represent the kinds of situation model updating required to make sense of a business situation and develop insights about it.

[1] We are indebted to Brad Tuttle for suggesting this learning objective to make the accounting relevance of the case more salient.

### Comparison with Other Cases

Because it embraces managerial issues and is a comprehensive case, we believe this case complements existing literature. For example, Borthick et al.'s (2001) website referral case and Borthick and Jones' (2007) wireless billing audit are primarily concerned with compliance and audit problems. While it concerns the managerial issue of a potential budget overrun, the Borthick and Jones (2005) warranty call center case does not include requirements for preparing a business process model, detecting and correcting data errors, constructing an REA model, implementing a database, or documenting procedures. In fact, the smaller scope of Borthick and Jones (2005) makes it an ideal case for developing students' query skills from an elementary level as in Borthick et al. (2001) to the level needed to work this case. Thus, because of differences in area and scope, we believe this case will be a welcome addition to the literature. Furthermore, even if some of the cases could be used interchangeably, we believe instructors would welcome the opportunity to rotate cases occasionally to minimize unauthorized collaboration across terms.

### Prerequisite Skills

To work the case, students need to have (1) REA modeling skills at the level of Romney and Steinbart (2006) or Dunn et al. (2005), (2) analysis skills and database querying proficiency at the level of Borthick and Jones' (2005) case investigating a possible budget overrun for a PC maker's warranty service call center, and (3) accounting skills (preparing journal entries) at the level of principles of accounting texts. Although the REA model in the teaching notes is represented using Crow's Foot notation (Rob and Coronel 2004), instructors can choose other notations such as Chen (1976) or Batini et al. (1992).

### Case Design Rationale

Although it contains a substantial number of rows, the database for the case was designed with just enough tables and attributes to represent the situation but without overwhelming detail. Like Borthick and Jones' (2005) warranty call center case, the tables in this case have too much data for hand manipulation of records.

The case is presented in three parts. In Part 1, learners (1) prepare a business process diagram (BPD), (2) identify business objectives to guide data analysis for assuring data quality and analyzing business performance, (3) construct an REA diagram to specify a database design and implement the database, (4) query the database to respond to the business questions, (5) document procedures for clerical staff, (6) prepare adjusting journal entries consistent with query results, (7) communicate query results to the grower for managing the business, and (8) optionally, evaluate other students' work. In Part 2, learners respond to a small set of multiple-choice questions as practice for answering the assessment questions in Part 3. Learning objectives for the questions in Parts 2 and 3 appear in Table 1.

### Reaction to the Case

Two key themes emerged from student feedback: the appeal of RFID technology and the realism of the case. The use of RFID technology is an effective way to develop student interest in analyzing data. After reading the background articles on RFID and thinking about the potential uses of RFID, students were engaged in working the case. A few students were so engaged they attempted to research investment opportunities related to RFID technology. The engagement engendered by the use of RFID technology is a key feature of the

**TABLE 1**
**BloomScape Questions by Learning Objective**

| Learning Objective | Question Number[a] |
|---|---|
| Design and Represent Business Processes | |
| Develop process implications | **7**, **10**, **4** |
| Make inferences about process behavior | **15**, **24** |
| Infer reasons for system design | 6 |
| Improve the system or processes | **25**, 28 |
| Evaluate business strategy | 8 |
| Design and Implement Databases | |
| Develop data structures | **16**, 20 |
| Match or convert data types | 9, **11** |
| Construct keys | 12 |
| Match cardinalities to business processes | **16**, **24** |
| Configure joins | **17**, **22**, **23**, **P5** |
| Query Databases to Provide Insights about Performance | |
| Develop business performance analysis objectives | S1, 5, **30** |
| Compose query strategy | 2 |
| Formulate queries | **15**, **21**, **22**, **23**, **P3**, **P5**, **P6** |
| Construct expressions | 18, 27, S4 |
| Interpret query results | **11**, **17**, **23**, **25**, **29**, **30**, **4**, **P3**, **P5** |
| Document queries for others to use | 26 |
| Evaluate Internal Control and Design Controls | |
| Develop data quality monitoring objectives | 1, 3, 13, 14, 19, **29** |
| Detect and correct data errors | **7**, **10**, **17**, S2, **29**, **P6** |
| Prepare Journal Entries Based on Query Results | P7, 31-36 |

[a] Question numbers in **bold** pertain to more than one learning objective. Question numbers beginning with "P" refer to practice questions.

case because student engagement is related to the amount of effort they exert, which is associated with learning.

Students were also caught up in the realism of the case. The case setting is vivid and familiar in the sense that students can imagine how BloomScape operates. Students also learn to recognize that technology does not solve all problems. For example, RFID readers may not detect all the tags, and BloomScape workers can forget to change the attributes identifying an order or its direction. Querying can, however, be used to help detect and correct errors as well as analyze business performance. The case helps students realize that knowing how to construct queries is not just an academic exercise but that query expertise is essential in performing accounting functions such as correcting data errors, analyzing business performance, and preparing journal entries. In addition, the case illustrates the difficulties engendered by the lack of integration across information systems.

Some students find the case to be the most challenging academic experience they have had, most likely because of its demands for the integration of modeling, analysis, querying, and sense-making skills. To keep challenged students working, we have found it helpful to reiterate how case activities are relevant to students' careers. Sometimes, the best counsel for struggling students comes from other students with work experience observing that the case is like real life and that they should use the case to begin learning how to cope with similar situations they are likely to encounter in their careers.

## II. IMPLEMENTATION GUIDANCE

### Course Use

The case is suitable for courses in (1) AIS and database systems for advanced undergraduate students and (2) AIS, database, and managerial courses for master's students. Ideally, students should have some familiarity with RFID, e.g., as explained in Romney and Steinbart (2006). Students need proficiency in (1) REA modeling at the level of Romney and Steinbart (2006) or Dunn et al. (2005), (2) database querying at the level developed by Borthick and Jones' (2005) case on investigating a possible budget overrun for a PC maker's warranty service call center, and (3) accounting skills in preparing adjusting journal entries at the level of principles of accounting texts. Although the REA model in the teaching notes is represented using Crow's Foot notation (Rob and Coronel 2004), instructors can choose other notations such as Chen (1976) or Batini et al. (1992).

The case can be used as an individual or as a team assignment. If students complete the multiple-choice questions in Part 3 individually as an in-class assessment of proficiency level, these questions can serve as a control on freeloading by team members on joint activities.

### Business Process Modeling Choice

The reason for the requirement to prepare a graphical representation of the business processes is for students to understand the business situation well enough to complete subsequent requirements. Without this understanding, students seem unable to make progress on the subsequent requirements.

Although the business process diagram can be created in several graphical formats, e.g., flowcharting or data flow diagramming, an approach that works well for this case is the Business Process Modeling Notation (BPMN) (BPMI 2004) developed by the Business Process Modeling Initiative's (BPMI) Notation Working Group (which has merged with the Object Management Group). In February 2006, BPMN 1.0 was adopted as an Object Management Group (OMG) standard. BPMN was designed specifically for business process modeling for use by business users, business analysts, technical developers, and business managers. In Bradford et al.'s (2007) framework, BPDs would be in the process-mapping category. The documentation in White's (2004) introduction, available at no cost from the BPMI website, is sufficient guidance for preparing the business process diagram (BPD) for this case.

Although flowcharting has been the dominant diagramming approach for business processes (Bradford et al. 2007), BPDs are becoming more common because of the ease of preparing and using them. The BPMN standard was designed to afford a single format for business users, business analysts, technical developers, and business managers and to facilitate the integration of documentation and software development platforms for maintaining consistency between the documentation and the system itself (Kalpic and Bemus 2002; Winters 2004). Krishnan et al. (2005) extended the BPMN notation to include representing internal controls explicitly, including the completeness, existence, and valuation error categories that a control eliminates and the information flows that a control spans. Given the potential for BPMN-based notation to specify executable business process models and to help auditors select key control sets for testing, we believe that the BPMN notation is appropriate for representing business processes in accounting systems (Krishnan et al. 2005).

### Database Modeling Choice: REA

From the possible approaches to modeling databases, we chose the Resources-Events-Agents (REA) model (McCarthy 1982) with its REA ontology (Geerts and McCarthy 1999, 2000) because of its applicability to accounting information systems and its history of use in accounting information systems (AIS) courses. The REA model has long been advocated as an approach for modeling enterprise information systems (David et al. 2002). The use of REA for modeling accounting information systems as pedagogy led to Professor McCarthy (2003) receiving an American Accounting Association Innovation in Accounting Education Award.

Although there are several diagrammatic notations for representing REA cardinalities, we chose the crow's feet notation of the Universal Modeling Language (UML) (Pender 2003) because of the ease of developing an REA diagram from it and its increasing use in software design tools and in AIS textbooks, e.g., Romney and Steinbart (2006). Other common notations include Batini et al. (1992) and Chen (1976). The Batini et al. (1992) notation shows cardinalities on the same side of the entity in the (min, max) form. The Chen (1976) notation is like Batini et al. (1992) except that the cardinality pairs are reversed or on the opposite side of the entity. The UML crow's foot notation is like Chen (1976) except for using crow's feet instead of N and minimum cardinalities appear closer to the center of the relationship and the maximum cardinalities, closer to the entities.

### Software Choice

Although they are supplied in the form of Microsoft Access® 2000 databases, the data can be used in subsequent versions of Microsoft Access or exported to any relational database system that supports querying with the Structured Query Language (SQL) or a Query-By-Example (QBE) interface. The teaching notes feature queries developed for Microsoft Access QBE. Given the growing use of database querying in business and in prerequisite courses, some students may already prefer one of these two interfaces. Instructors can permit use of either one or require students to use a specified one. Differing preferences across team members prompt them to negotiate their choice of tool interface.

### Case Staging

Students can work the case as a single assignment or as multiple assignments. The single-assignment approach has the advantage of enabling students to experience the case as an integrative whole, in which the completeness of their lists of objectives for assuring data quality and analyzing business performance affects querying outcomes. The multiple-assignment approach allows instructors to help students that might need coaching on how to approach tasks in situations for which the mental model construction requires inferences and elaborations. Thus, a multiple-assignment approach has the advantage of ensuring that student lapses early in the case do not jeopardize subsequent performance. For example, if students get feedback on their lists of objectives for assuring data quality and analyzing business performance, they will develop a more complete set of results. The feedback could be in the form of discussion in class or on a discussion board. Because students typically make sense of different aspects at different times, they can respond to each other's questions.

For a multiple-assignment approach, phase 1 might encompass the objectives of (1) prepare a business process diagram and (2) develop objectives for assuring data quality and analyzing business performance. Phase 2 might include the objectives of (3) construct a database model and implement it in a database. Phase 3 would then include objectives (4) query the database to satisfy the objectives for assuring data quality and analyzing business performance, (5) document querying procedures, (6) prepare adjusting journal entries consistent with query results, (7) communicate the results in a report, and (8) optionally, evaluate other students' work.

**Time Requirements**

The time that students spend on the case is highly variable, depending on (1) their skills in REA modeling and database querying and (2) their propensity to procrastinate. Students with the suggested levels of skill in REA modeling and database querying typically spend 15 to 20 hours on the case. Students without the prerequisite skills that want to do good work may spend 40 or more hours on the case, where about half the hours are spent developing the needed skills. Students without the prerequisite skills that are satisfied with ordinary work may spend 10 to 20 hours on the project.

Independent of their modeling and querying skills, students that defer working on the case until the last weeks before it is due tend to report more hours than those that pace their work more uniformly. Procrastinators forgo opportunities to get answers to their questions in the earlier weeks that they can ask questions about the case in class sessions and on an electronic discussion board. Doing all the work at the end also eliminates time for reflection, which can trigger epiphanies about how to proceed with the case. The combination of not being able to get answers to questions on short notice and not reflecting on case aspects results in procrastinators missing out on insights that would enable them to minimize the hours they spend on the case. Of course, instructors can ensure that students do not defer all the work to the end of the assignment period by requiring submissions of sub-parts at intervals for grading as explained in the previous section. Sparing procrastinators from the consequences of deferring the work, however, eliminates an opportunity for students to learn to manage time effectively.

**Peer Evaluation of the Case (Optional)**

Having students evaluate other students' work facilitates students recognizing that there may be multiple ways to approach different tasks. A report form for peer evaluation of the case is included with the case materials. If students publish their work on websites, e.g., on institutionally provided web spaces or in a learning management system, the instructor could create a page linking to all students' work, which facilitates giving students access to everyone's work. For each team, the instructor can designate the team whose work it is to evaluate. Students can complete this kind of evaluation in about 30 minutes. The linking page can also include links to completed evaluation reports. Class time permitting, student teams could summarize their evaluations briefly (5–10 minutes) for the class. We prefer this approach to having teams present their work because it focuses students' attention on evaluating others' work, which ensures that students see other ways to accomplish the same tasks, including the best approaches developed by other teams.

**Case Nuances and Coaching Learners**

Students may not, at first, be able to develop objectives for assuring data quality and for analyzing business performance or distinguish between the two kinds of objectives. Working through an example of each kind of objective is usually enough coaching to help students distinguish between them. We recommend a class discussion of developing the objectives. Another way to help students with the objectives is to make one or more of each kind available to them, e.g., on the reporting template.

Because learners typically start at different places with respect to their skills for analyzing a business situation to develop querying objectives, for structuring databases, and for developing queries and making sense of their results, instructors should be ready to provide targeted coaching for varied skill levels. Instructors can choose how and when in the life of the project they offer different kinds of guidance to learners. Rather than simply telling learners how to do something, however, helping them construct their own mental models of the situations or tasks will enhance their ability to construct models for subsequent situations on their own. One way to guide construction of mental models is to prompt learners to make connecting inferences by asking them questions that step them through the model. The questions in Table 2 illustrate the kinds of questions that instructors could pose to students to prompt them to construct their own mental models of the situation and the needed analysis.

**TABLE 2**
**Questions for Prompting Learners to Construct Mental Models**

Making Sense of the Situation

1. From the conversation, what are BloomScape's data analysis needs?
2. What are the implications of not detecting and correcting any data errors?

Developing Objectives

1. Why is it important to develop objectives first?
2. How do you decide what the objectives are?
3. How can you use the conversation to develop potential objectives?
4. What distinguishes objectives for assuring data quality from objectives for analyzing business performance?
5. What mistakes could workers at the RFID PC make and how might they be recognized and corrected?

Constructing the BPD and the REA Diagram

1. How do you figure out what the business events are? Where are the clues? How do you recognize them?
2. Although the take order event occurred before the conversation started, are resources needed for it and for items ordered?
3. Is a compost resource needed or will the plant type (inventory) resource do?

Designing Tables and Querying the Data

1. How do you make all the tables appear in the same database so you can work with them?
2. Can query results be used as tables? How?
3. Where are the SKUs in the RFID data? How do you extract the SKU from the GTIN? Does data type matter? If so, what do you do about it?
4. What are the hardest entities to create? How can you create them with queries rather than manual data entry?
5. Does it matter that queries do not have explicit primary keys? Why? What substitutes for them?
6. Does it matter whether data quality is assured *before* business performance is analyzed? Why?

Preparing Documentation

1. Who is the audience for the documentation?
2. How knowledgeable is this audience about database querying? What kind of explanations of using Access would this audience understand?
3. How do you explain what to look for in query results even though the next set of RFID data my have different data errors?

Preparing Adjusting Journal Entries

1. Depending on query results, what adjusting journal entries might be required to reflect operational outcomes represented by the RFID scanning?
2. Are all of the potential adjusting journal entries already represented by query objectives? If not, what query objectives are needed to complete the adjusting journal entries?

## III. THE CASE

### The Business Situation

*The scene: Managers at BloomScape, a company that grows and supplies bedding plants such as pansies and begonias to big-box retailers, mulling over the implications of using RFID[2] to track the carts with flats of plants they deliver to customers and how to take advantage of the avalanche of data[3] that tag reading could generate. Other growers are already using RFID to track carts.*

Hitomi (greenhouse manager): "Do we have to redo our SKUs to use RFID?"

Kelly (IS manager): "Instead of 'redo,' it's more like 'embed,' as in the current SKUs being embedded in a larger ID number. Each cart and each flat of plants will have a tag with the ID number."

Chandra (sales manager): "Does that mean we could track products to the flat? With that information, I might be able to convince big-box staff that we really did deliver what they ordered in the delivery window."

Lane (shipping manager): "What makes you so sure you'll get 100% reading for carts?"

Kelly: "I'm going on what another grower achieved with antennas built into the floor at loading docks. As carts pass the readers, the antennas broadcast signals to nearby PCs, which record the data."

Hitomi: "What records do the PCs keep?"

Kelly: "If it works right, they record all the RFID tags—on carts and on flats—that pass close enough to be read."

Lane: "How do you distinguish between a full cart headed out and an empty cart coming back?"

Kelly: "A worker at the loading dock would do it at a PC, which means changing the settings for each shipment to associate it with an order by orderID and indicating whether the shipment is outbound to the customer or empty carts are returning to us."

Hitomi: "What about tags on the flats of plants? How well will they read?"

Kelly: "It's not clear yet. I don't think anybody's expecting 100% reading at that level at first. The most common errors are omissions. If the reader sees a working tag, it usually reads it correctly. We may have to experiment with the best position for the tags on flats. We already know that the tags on the bottom of carts should be embedded in a plastic sleeve."

Lane: "Why?"

Kelly: "Metal surfaces tend to scatter the signals, and the plastic sleeve gets the tag ever so slightly off the surface of the metal."

Lane: "Okay, you convinced me that RFID will help us keep up with carts. What else is possible?"

Chandra: "Could we determine how long carts stay at customer stores and with which products? Knowing the quantity and frequency of cart traffic to and from stores would let us do a cost and profitability analysis by customer."

Lane: "What about carts hanging around empty at stores?"

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[2] Levinson, M. 2003. The RFID imperative. *CIO*: 78-91. Available at http://www.cio.com/archive/120103/retail.html

[3] Whiting, R. 2004. Data avalanche. *InformationWeek* 30-36. Available at http://www.informationweek.com/story/showArticle.jhtml?articleID=17700027

Hitomi: "Well, maybe organizing some of this data would let us keep closer tabs on carts, so we could retrieve them before they disappeared into cart heaven at $500 apiece."

Lane: "Back to the financial breakdown part. Do you mean we don't already know the cost and profitability per customer?"

Kelly: "That's right! If it makes you feel any better, not many companies, large or small, know that."

Chandra: "Why not, given all the data that companies collect?"

Kelly: "Before ERPs were invented, the data fields you'd need for these calculations were scattered across different systems, making it hard to isolate just the relevant data."

Chandra: "And after ERPs came?"

Kelly: "Even though ERPs integrate across applications, getting the data out is still non-trivial because somebody that knows what they're doing with the underlying database has to write reports based on queries to retrieve it."

Chandra: "If ERPs are so integrated, why do you have to get the data out to analyze it?"

Kelly: "Because ERPs, for the most part, haven't been modified to accept RFID data. Even big companies are still analyzing RFID data in a separate database. And, even though it might be theoretically possible to get to the data, no one has much experience with this kind of calculation. We'd be breaking new ground."

Hitomi: "Like putting a shovel in brick-hard clay?"

Kelly: "Yep! Let's see how far we can get thinking through what the calculations might be. Part of the computation would include factoring in plant loss. Now, we just compost the returns. With RFID, we'd count returned flats before composting what's left of the plants. Beats me why we can't keep plants looking good long enough for our customers to sell them."

Lane: "Maybe they hide them!"

Chandra: "Or we don't water them consistently. Um [obviously thinking] wonder if it varies by store."

Kelly: "Is this enough to get you thinking about the possibilities? We can configure the PCs to record carts and flats outbound and inbound, stripped of duplicate signals. I have no idea when our accounting software will be upgraded to accept RFID data—could be a long time given the data-formatting issues and software incompatibilities. There are fancy report-writing programs we could get to analyze the data, but they're expensive, and it's not clear to me which one we'd really need."

Chandra: "Wouldn't the cheapest one do?"

Kelly: "I don't know because I don't know just what kind of analyses will be useful and what the data volumes will be. We've just talked about some analysis needs, but talking is not the same as analyzing."

Chandra: "Is there an alternative to get us started?"

Kelly: "Maybe. If someone imported data into a database and analyzed it with queries, we might get some insight into useful analyses and data volume."

Chandra: "Do we have anybody that can do that?"

Kelly: "I can get the data extracted. I don't have anyone for the querying at the moment, but my neighbor teaches accounting information systems at the university. I'll see if she has students that might be interested."

Chandra: "I know it will take a while, maybe a long while, but I can't wait until we can enjoy RFID benefits. If Wal-Mart reduced its out-of-stocks with RFID, we ought to see some gains too!"

Hitomi: "Be patient. This is going to be like growing plants—sssllllooowww."

*Later, after Hitomi, Chandra, and Lane realized they needed to know more about tag reading.*

Lane: "I know just enough about this stuff to be dangerous! I'm looking at a tag whose paper bar code says '01564830104 74.' If I mentally drop the '4' in the 1's position, the last four digits are '1047,' which corresponds to our SKU of '1047,' which is Majestic Giant red/black blotch 6-pack."

Kelly: "You got it! The number on the bar code is the Global Trade Item Number (GTIN), which is what the tag tells the reader, and the PC writes in its file. The item number is actually '01047.' The numbers in front of the item number are country and company codes, and the last digit, the '4' you stripped off, is the check digit."

Chandra: "Does every flat of Majestic Giant red/black blotch 6-pack have the same GTIN?"

Kelly: "Yes."

Chandra: "Then how does the tag reader keep up with the fact that one cart might have several flats with the same GTIN? We usually put like plants together on a shelf, e.g., seven 6-pack flats fill a shelf."

Kelly: "When a tag passes within range, the reader and tag do a little dance called the Q protocol. The reader issues a query to the tag, which responds with a randomly generated number. The reader acknowledges the number, after which the tag sends its ID. When the reader gets the ID, it tells the tag to be 'quiet,' which makes it easier for the reader to hear all the tags and be sure it read all of them. Because each tag generates its own random number, the reader can keep up with each tag it read. Although the cycle might be repeated several times, carts and flats are supposed to be recorded once."

Hitomi: "How many tags can a reader handle at once?"

Kelly: "Theoretically, the number is 1,000 tags per second in the best conditions although we don't need to run ours at that speed. Something in the 100–500 range is more likely."

Hitomi: "In other words, the reader ought to be able to keep up with a dock worker pushing carts out the door to a delivery truck."

**Required**

***Part 1: Data Cleansing and Analysis***

1. Model the business process by preparing a one-page business process diagram (BPD)[4] for aspects of the process revealed in the situation.
2. Develop objectives for assuring data quality and analyzing business performance to respond to the managers' needs as represented by the conversation. Assuring data quality pertains to detecting and correcting data errors as early as possible in the business process. Analyzing business performance pertains to measuring how well the business process is working and how profitable it is. [As a benchmark,

[4] For BPD conventions, see White, S. A. 2004. *Introduction to BPMN*. Aurora, CO: BPMI. Available at http://www.bpmi.org/downloads/Introduction_to_BPMN89.pdf.

superior performance would include seven data-quality objectives and 16 business-performance objectives.]

3. Construct a database model for the data in the form of an REA diagram that integrates the data from the existing system (systemExtract.mdb, data attributes in Figure 1) and the data from RFID (RFID.mdb, data attributes in Figure 2). If

**FIGURE 1**
**Data Attributes: SystemExtract.mdb**

| Table/Attribute[a] | Explanation |
|---|---|
| **buyer**: Buyers of BloomScape's plants | |
| **buyerID** | Unique identifier for a buyer |
| company | Big-box retail company that employs a buyer |
| **cart**: Carts for delivering plants to customers | |
| **cartID** | Unique identifier for a cart |
| dateAcquired | Date a cart was acquired |
| cost | Cost of a cart |
| residualValue | Residual value of a cart |
| life | Life in years of a cart |
| depMethod | Depreciation method for a cart |
| period | Frequency of system booking of depreciation expense |
| **COA**: Chart of accounts for the accounting system | |
| **acctID** | Unique identifier for an account |
| acctName | Name of an account |
| **flat**: Plastic tray for grouping plants in plastic liners | |
| **flatID** | Unique identifier for a kind of flat |
| type | Kind of liners that go in a flat |
| unitsPerFlat | Number of liners in a flat |
| flatsPerShelf | Number of flats that fill a cart shelf |
| **order**: Orders for plants received from retailers | |
| **orderID** | Unique identifier for an order |
| buyerID | Unique identifier for a buyer |
| buyerOrderID | A buyer's purchase order identifier |
| storeID | A buyer's identifier for its store |
| orderDate | Date the order was received |
| requestDate | Date the buyer requests delivery of the order |
| orderTotal | Dollar price of the order to a buyer |
| **orderItem**: Item ordered | |
| **orderID** | Unique identifier for an order |
| **SKU** | Stock keeping unit, unique identifier for an item |
| quantity | Quantity of flats ordered |
| **plantType**: Price list from which buyers order | |
| **SKU** | Stock keeping unit, unique identifier for an item |
| plant | Genus of plant |
| description | Description of plant |
| flatID | Unique identifier for a kind of flat |
| flatPrice | Price to buyer for a flat of plants |
| flatCost | Cost for producing a flat of plants |

[a] Table names and primary keys in **bold**.

**FIGURE 2**
**Data Attributes: RFID.mdb**

| Table/Attribute[a] | Explanation |
|---|---|
| **RFID**: Transactions recorded through RFID readers | |
| **ID** | Unique identifier for a record |
| date | Date of transaction |
| orderID | Unique identifier for an order |
| direction | Direction of movement of cart: 'del' for delivery outbound, 'ret' for return of cart |
| cartID | Unique identifier for a cart, sensed by RFID |
| GTIN | Global Trade Item Number, the unique identifier for an item, sensed by RFID |
| quantity | Number of flats of a GTIN on a cart |

[a] Table names and primary keys in **bold**.

cardinalities are not specified in the conversation, use normal REA patterns between events to specify them. Implement the model in a relational database in Access.

Where existing tables corresponding to the needed entities, use them with their original names. Where data structures need to be rearranged or restructured, do so with queries and show the resulting query as the entity name on the REA diagram.

Buyers are responsible for multiple stores for their companies, and all stores in the order table are valid. BloomScape has sufficient plant inventory to fill the orders. To minimize database complexity, no data were extracted from the system about inventory levels, stores, store employees, or BloomScape order takers or greenhouse workers. To indicate the lack of data for an entity, e.g., store employees, show the entity symbol with a dashed line rather than a solid line.

4. Create and debug queries for satisfying the objectives identified in 2 above for (1) assuring data quality and (2) analyzing business performance.
5. Document the following aspects of working with the data and your queries for clerks so that they can assume responsibility for them:
   a. Importing data into the database
   b. Detecting and correcting data errors
6. Prepare adjusting journal entries as of BloomScape's year-end date of 12/31 consistent with query results to reflect operational results. Include dates, account numbers and names, amounts, query names, and explanations. The purpose of the journal entries is to adjust the accounts to make them consistent with operating results represented by the RFID scanning and correction of errors in the RFID data. No subsequent RFID transactions pertained to any of the orders in the supplied databases. Carts not returned by year-end should be written off as of the end of the year.
7. Communicate your outcomes in the report format in Figure 3.
8. Optional: Evaluate another team's BloomScape work by completing the report format in Figure 4. The instructor will identify the team whose work you are to evaluate.

**FIGURE 3**
**BloomScape Report**

| | |
|---|---|
| **1** | **Business process diagram (BPD)** |
| **2** | **Objectives for assuring data quality and analyzing business performance** |
| **Objectives for assuring data quality** | |
| [here, numbered list of objectives] | |
| **Objectives for analyzing business performance** | |
| [here, numbered list of objectives] | |
| **3** | **REA diagram** |
| **4** | **Assuring data quality** |

| | **Objectives for assuring data quality** (Use objectives from above.) | **Explanation of the query strategy in terms of manipulating database attributes** (Include names of queries.) | **Results from executing queries and implications of the results** (Show specific numerical results, in tables if there are more than a few numbers.) |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | [add/delete rows as needed] | | |

| | | | |
|---|---|---|---|
| **5** | **Analyzing business performance** | | |
| | **Objectives for analyzing business performance** (Use objectives from above.) | **Explanation of the query strategy in terms of manipulating database attributes** (Include names of queries.) | **Results from executing queries and implications of the results** (Show specific numerical results, in tables if there are more than a few numbers.) |
| 1 | | | |
| 2 | | | |
| 3 | [add/delete rows as needed] | | |

| | |
|---|---|
| **6** | **Documentation for clerks** |
| [Documentation for clerks here] | |
| **7** | **Adjusting journal entries** |

| **#** | **Date** | **Amount/account to debit** | **Amount/account to credit** | **Query names** | **Explanation** |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| [add/delete rows as needed] | | | | | |

**Time log** (hours spent on this assignment, by person)

| **Name** | **Total hours** |
|---|---|
| | |
| | |
| [add/delete rows as needed] | |

**FIGURE 4**
**BloomScape Evaluation Report**

| **Evaluation of the work of *Team x*** | **Completed by *Team y*** |
|---|---|
| **Exemplary aspects** | **Incomplete, misguided, or nonfunctional aspects** |
| **BPD** | |
| [Exemplary aspects of BPD here]] | [Incomplete, misguided, or nonfunctional aspects of BPD here. Include an explanation of how to remedy these aspects.] |
| **Objectives for assuring data quality** | |
| | |
| **Objectives for analyzing business performance** | |
| | |
| **REA diagram** | |
| | |
| **Queries and results for assuring data quality** | |
| | |
| **Queries and results for analyzing business performance** | |
| | |
| **Documentation for clerks** | |
| | |
| **Adjusting journal entries** | |
| | |

### *Part 2: Practice Objective Questions*

The following questions are for student practice in answering objective questions. Alternatively, these questions could be combined with the objective questions for assessment purposes.

1. With respect to profitability analysis, an allocation of cart use should be:
   a. Excluded because the cost is not controllable
   b. Excluded to avoid analysis for small values
   c. Included to match revenues and expenses
   d. Included because the cost is controllable
2. Suppose querying detects errors or inconsistencies in the RFID table. The best approach for handling them is to:
   a. Correct, with queries, errors and inconsistencies for which there is sufficient information to reconstruct the values and document errors and inconsistencies for which values cannot be reconstructed
   b. Document all errors and inconsistencies and correct, in the RFID table, those for which there is a reasonable basis for what the values should have been.
   c. Correct, in the RFID table, errors and inconsistencies for which there is sufficient information to reconstruct the values and document errors and inconsistencies for which values cannot be reconstructed

   d. Document all errors and inconsistencies and correct, with queries, those for which there is sufficient information to reconstruct the values
3. The best statement about the variation in returned plants is that they varied:
   a. Randomly across stores
   b. Randomly across buyerIDs
   c. Non-randomly across buyerIDs
   d. Randomly across orderIDs
4. Suppose a cartDeployed query contains orderID, cartID, and dateDeployed. Suppose a cartReturned query contains orderID, cartID, and dateReturned. To calculate the whole days, carts are in use where a portion of a day is treated as a whole day, the best expression is:
   a. Round(CInt(([cartReturned.dateReturned]-[cartDeployed.dateDeployed])))
   b. Round(CInt(([cartReturned.dateReturned]-[cartDeployed.dateDeployed])+0.5))
   c. Round(([cartReturned.dateReturned]-[cartDeployed.dateDeployed]))
   d. Round(([cartReturned.dateReturned]-[cartDeployed.dateDeployed])+0.5)
5. Suppose the cartDeployed query and the cartReturned query defined in the previous question were linked on cartID with a default join. Suppose the query, named cartDaysUsed, includes a new attribute cartDays for calculating the number of days carts are in use. Creating another query averageCartDays with orderID (with Group By) and cartDays (with Avg) gives a result that:
   a. Understates average cart use
   b. Calculates average cart use correctly
   c. Overstates average cart use
   d. Is not assessable for correctness
6. Suppose some errors were detected in direction values in the RFID table. The best approach for correcting the errors would be to:
   a. Query the RFID table to create a query result without the errors, rerun the cartDeployed and cartReturned queries on the corrected data, and rerun the error detection query to verify error correction
   b. Edit the RFID table to create a table without the errors, rerun the cartDeployed and cartReturned queries on the corrected data, and rerun the error detection query to verify error correction
   c. Query the RFID table to create a query result without the errors, rerun the cartDeployed and cartReturned queries on the corrected data, and inspect the cartDeployed and cartReturned queries to verify error correction
   d. Edit the RFID table to create a table without the errors, rerun the cartDeployed and cartReturned queries on the corrected data, and inspect the cartDeployed and cartReturned queries to verify error correction
7. Given the operational results represented in the RFID data, failing to make adjusting journal entries would most likely lead to:
   a. Overstated assets and understated net sales
   b. Overstated assets and overstated net sales
   c. Understated assets and understated net sales
   d. Understated assets and overstated net sales

***Part 3: Objective Questions***

To maximize instructor flexibility, the objective questions appear in the teaching notes. Instructors could use all the questions for assessment of learning at the completion of the case or select questions for students to work on at different stages of the case to guide them in making sense of the business situation, mapping data relationships to the business situation, identifying query objectives, and formulating queries.

## IV. TEACHING NOTES

The Teaching Notes available online for this case include:

1. The text of:
   a. Nuances of modeling the business situation, including a table of REA elements by database table name
   b. Part 1
      i. A business process diagram
      ii. An REA diagram
      iii. A completed report
      iv. Point allocations with and without peer evaluation
   c. Part 2 Solutions for practice objective questions with response-level feedback
   d. Part 3 Objective questions and solutions with response-level feedback
2. A link to a zipped file containing the following files:
   a. Visio files for the BPD and REA diagram
   b. Access mdb files containing the data for student querying
   c. Access mdb file containing the data and QBE queries for instructor use that supports the Part 1 analysis of querying
   d. Word file containing the Part 2 practice questions, Part 3 objective questions, solutions, and response-level feedback
   e. HTML files of the case text to enable instructors to stage the case on a website. Websites used for this purpose should be password-protected, and the passwords should be given only to students enrolled in courses using the case.

## V. SUMMARY

This case was created with the high-level objective of learning to model business situations to design databases and query them to solve business problems. The case, based on the context of RFID for tracking flats of plants and carts transporting them, affords an opportunity for learners to experience solving a problem from beginning to end, i.e., from deciding what the problem is by modeling the business process and developing querying objectives to querying a database they designed and implemented, interpreting query results, and preparing adjusting journal entries. The case is workable by learners with moderate query skills and includes multiple-choice questions for assessing learners' proficiency by sub-objective. The case responds to the need for learning experiences that help students develop skills for analyzing transaction data to solve business problems and exploit business opportunities.

## TEACHING NOTES

Teaching Notes are available only to full-member subscribers to the Journal of Information Systems through the American Accounting Association's electronic publications system at http://www.atypon-link.com/action/showPublisherJournals?code=AAA. Full member subscribers should use their personalized usernames and passwords for entry into the system where the Teaching Notes can be reviewed and printed.

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## REFERENCES

Barsalou, L. W. 1999. Language comprehension: Archival memory or preparation for situated action? *Discourse Processes* 28 (1): 61–80.

Batini, C., S. Ceri, and S. B. Navathe. 1992. *Conceptual Database Design: An Entity-Relationship Approach.* San Francisco, CA: Benjamin Cummings.

Borthick, A. F. 1992. Helping users get the information they want, when they want it, in the form they want it: Integrating the choice and use of information. *Journal of Information Systems* 6 (2): v–ix.

———. 1996. Helping accountants learn to get the information managers want: The role of the accounting information systems course. *Journal of Information Systems* 10 (2): 75–85.

———, D. R. Jones, and R. Kim. 2001. Developing database query proficiency: Assuring compliance for responses to website referrals. *Journal of Information Systems* 15 (1): 35–56.

———, and ———. 2005. Analyzing a potential warranty call center budget overrun: Using database queries to solve business problems. *Journal of Information Systems* 19 (1): 97–111.

———, and ———. 2007. Creating a business process diagram and database queries to detect billing errors and analyze calling patterns for cell phone service. *Journal of Information Systems* 21 (1): 102–122.

Bose, I., and R. Pal. 2005. Auto-ID: Managing anything, anywhere, anytime in the supply chain. *Communications of the ACM* 48 (8): 100–106.

BPMI, Business Process Management Initiative. 2004. *Business Process Modeling Notation (BPMN) Version 1.0.* Aurora, CO: BPMI. Available at http://www.bpmi.org/downloads/BPMN-V1.0.pdf.

Bradford, M., S. B. Richtermeyer, and D. F. Roberts. 2007. System diagramming techniques: An analysis of methods used in accounting education and practice. *Journal of Information Systems* 21 (1): 173–212.

Chen, P. 1976. The entity-relationship model—Toward a unified view of data. *ACM Transactions on Database Systems* 1 (1): 9–36.

Cooper, B. L., H. J. Watson, B. H. Wixom, and D. L. Goodhue. 2000. Data warehousing supports corporate strategy at First American Corporation. *MIS Quarterly* 24 (4): 547–567.

David, J. S., G. J. Gerard, and W. E. McCarthy. 2002. Design science: An REA perspective on the future of AIS. In *Research Accounting as an Information Systems Discipline*, edited by V. Arnold, and S. G. Sutton, 35–63. Sarasota, FL: American Accounting Association.

Dunn, C. L., and W. E. McCarthy. 1997. The REA accounting model: Intellectual heritage and prospects for progress. *Journal of Information Systems* 11 (1): 31–51.

———, J. O. Cherrington, and A. S. Hollander. 2005. *Enterprise Information Systems: A Pattern Based Approach.* Burr Ridge, IL: McGraw-Hill/Irwin.

Fennel, N. I. 2003. Make your data pay. *Internal Auditor* (June): 55–59.

Geerts, G. L., and W. E. McCarthy. 1999. An accounting object structure for knowledge-based enterprise models. *IEEE Intelligent Systems* (July/August): 89–94.

———, and ———. 2000. Augmented intensional reasoning in knowledge-based accounting systems. *Journal of Information Systems* 14 (2): 127–150.

Gernsbacher, M. A. 1997. Two decades of structure building. *Discourse Processes* 23: 265–304.

Graesser, A. C., K. K. Millis, and R. A. Zwaan. 1997. Discourse comprehension. *Annual Review of Psychology* 48: 163–189.

Jackson, R. A. 2004. Get the most out of audit tools. *Internal Auditor* (August): 36–47.

Johnson-Laird, P. N. 1983. *Mental Models: Towards a Cognitive Science of Language, Inference, and Consciousness, Cognitive science series; 6.* Cambridge, MA: Harvard University Press.

Kalpic, B., and P. Bemus. 2002. Business process in industry—The powerful tool in enterprise management. *Computers in Industry* 47 (3): 299–318.

Klamm, B. K., and M. L. Weidenmier. 2005. ERP lockup: Planning successful data jailbreaks. *Strategic Finance* 87 (1): 49–53.

Krishnan, R., J. Peters, R. Padman, and D. Kaplan. 2005. On data reliability assessment in accounting information systems. *Information Systems Research* 16 (3): 307–326.

McCarthy, W. E. 1982. The REA accounting model: A generalized framework for accounting systems in a shared data environment. *The Accounting Review* 57 (3): 554–577.

———. 2003. The REA modeling approach to teaching accounting information systems. *Issues in Accounting Education* 18 (4): 427–441.

McCollum, T. 2002. Data analysis with SQL. *Internal Auditor* (August): 25–27.

McKinnon, S. M., and W. J. Bruns. 1992. *The Information Mosaic.* Boston, MA: Harvard Business School.

Myers, J. L., M. Shinjo, and S. A. Duffy. 1987. Degrees of causal relatedness and memory. *Journal of Memory and Language* 26: 453–465.

Pender, T. 2003. *The UML Bible.* Indianapolis, IN: Wiley and Sons.

Rob, P., and C. Coronel. 2004. *Database Systems: Design, Implementation, and Management.* Boston, MA: Course Technology (Thomson Learning).

Romney, M. B., and P. J. Steinbart. 2006. *Accounting Information Systems.* Tenth edition. Upper Saddle River, NJ: Prentice Hall.

Speier, C., and M. G. Morris. 2003. The influence of query interface design on decision-making performance. *MIS Quarterly* 27 (3): 397–423.

Sullivan, L. 2004. Reaching down the supply chain. *InformationWeek* 49–52.

van Dijk, T. A., and W. Kintsch. 1983. *Strategies of Discourse Comprehension.* New York, NY: Academic Press.

White, S. A. 2004. *Introduction to BPMN.* Aurora, CO: BPMI. Available at http://www.bpmi.org/downloads/Introduction_to_BPMN89.pdf.

Winters, B. 2004. Choose the right tools for internal control reporting. *Journal of Accountancy* 197 (2): 34–40.

Wixom, B. H., and H. J. Watson. 2001. An empirical investigation of the success factors for data warehousing. *MIS Quarterly* 25 (1): 17–41.

Zwaan, R. A., and G. A. Radvansky. 1998. Situation models in language comprehension and memory. *Psychological Bulletin* 123 (2): 162–185.